Colorado Technical University

CS683 – Data Warehouse

Colorado Technical University
Instructor: Dr. John Conklin
Unit 4 – Data Analysis

Agenda

- OLAP
  - Defined
  - Overview
  - OLAP Process
  - Types
    - MOLAP
    - ROLAP
    - Hybrid OLAP
    - Other Types
  - Cubes
  - In Business Intelligence
  - Architecture
- OLAP tools to query data warehouse
  - Functionality
  - Popular Tools
  - Selection Process

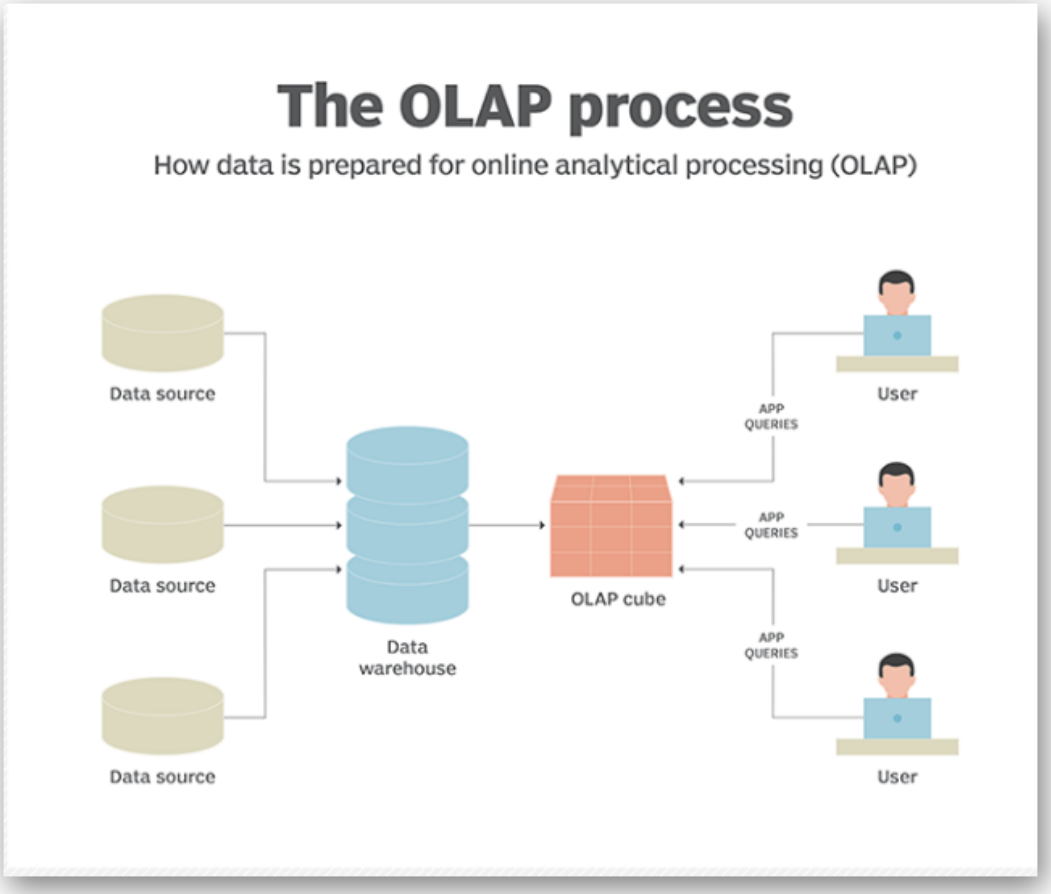
Agenda (cont.)

- Data Analysis
  - Defined
  - Methods/Process
  - Techniques
  - Types
  - Tools

ONLINE ANALYTICAL PROCESSING (OLAP)

OLAP Process

This image shows the OLAP process and how the data is prepared for online analytical processing.



(https://searchdatamanagement.techtarget.com/definition/OLAP)

OLAP Defined

“Online analytical processing, or **OLAP** , is an approach to answer multi-dimensional analytical (MDA) queries swiftly in computing. OLAP is part of the broader category of business intelligence, which also encompasses relational databases, report writing and data mining.

Typical applications of OLAP include business reporting for sales, marketing, management reporting, business process management (BPM), budgeting and forecasting, financial reporting and similar areas, with new applications emerging, such as agriculture.

The term *OLAP* was created as a slight modification of the traditional database term online transaction processing (OLTP).” (wikipedia.org)

OLAP Overview

- OLAP enables users to analyze multidimensional data from multiple perspectives.
- Consists of three basic analytical operations:
  - ***Consolidation (roll-up):*** involves aggregation of data which can be accumulated and computed in one or more dimensions.
  - ***Drill-down***: a technique that allows users to navigate through the details.
  - ***Slicing and Dicing***: a feature where users can take out (slice) a specific set of data from the OLAP cube and view (dice) the slice from different viewpoints.
- A fourth operation is often available was well and it is the Pivot function.
  - Used in analysis to gain a new view of the data by rotating the data axes of the data cube.
- Databases that are configured for OLAP use a multidimensional data model.
- The term OLAP was introduced in 1993 by E. F. Codd and along with this he proposed 12 criteria to define an OLAP database.

OLAP Overview

- Codd's 12 Rules:
  - Multidimensional conceptual view
  - Transparency
  - Accessibility
  - Consistent reporting performance
  - Client/server architecture
  - Generic Dimensionality
  - Dynamic space matrix handling
  - Multi-user support
  - Unrestricted cross-dimensional operations
  - Intuitive data manipulation
  - Flexible reporting
  - Unlimited dimensions and aggregation levels.

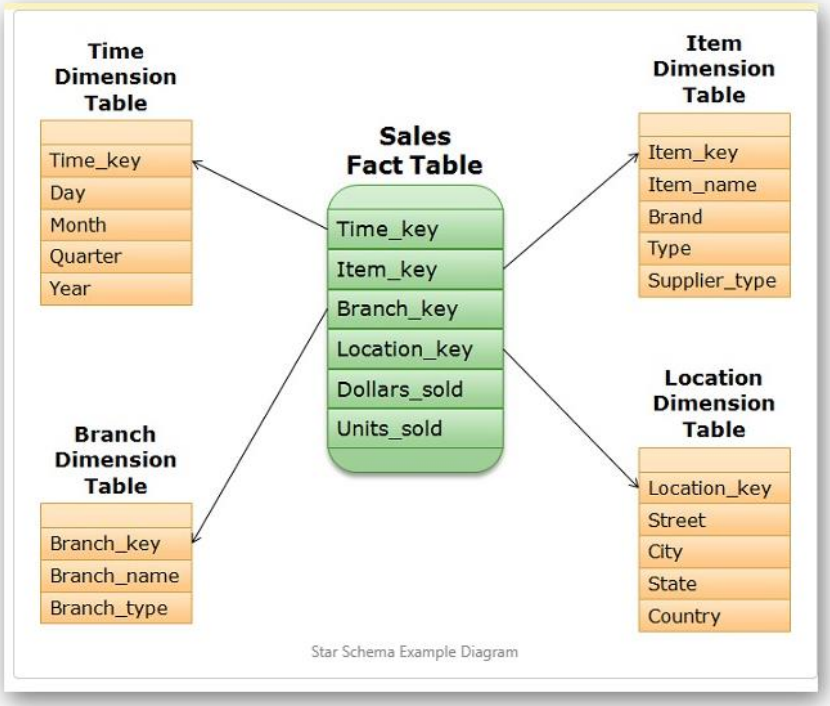
OLAP Overview (cont.)

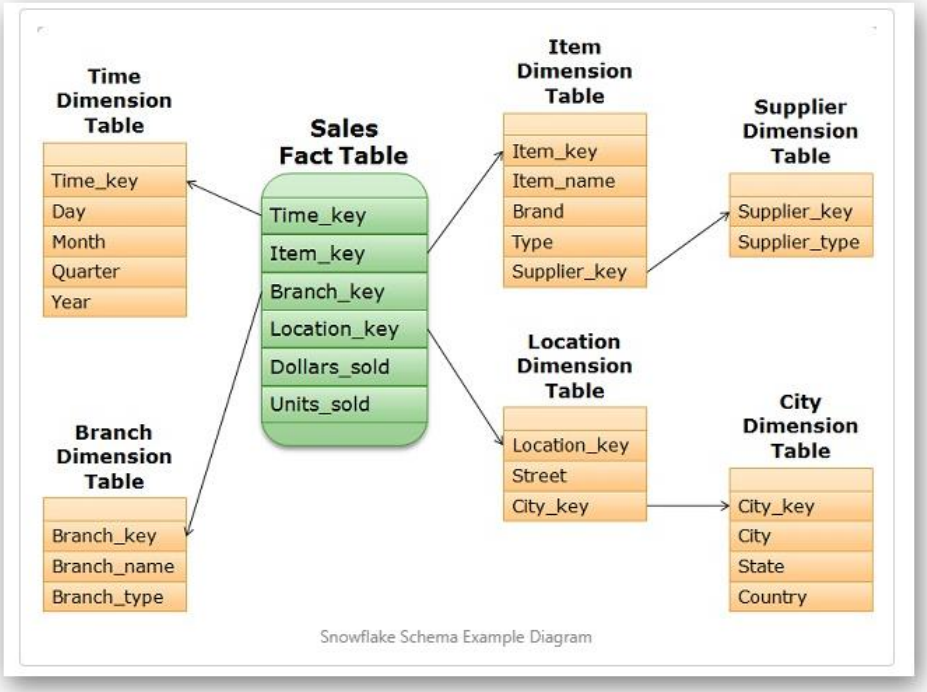
- Is typically contrasted to OLTP (online transaction processing) which is categorized by much less complex queries, in a much larger volume, to process transactions rather than having the purpose of business intelligence or reporting.
- OLAP clients may include spreadsheet programs like Excel, web application, SQL dashboards tools, etc..
- OLAP can also be used for the data mining or discovery of previously undiscerned relationships between the data items.

- OLAP Systems
  - At the core of the OLAP systems is the OLAP Cube.
  - Consists of numeric facts called ***measures*** which are categorized by ***dimensions***.
  - The cube metadata is typically created from a ***start schema*** or ***snowflake schema***.
  - Measures are derived from the records in the fact table and then dimensions are derived from the dimension tables.

OLAP Overview (cont.)

Star Schema / Snowflake Schema





(https://techdifferences.com/difference-between-star-and-snowflake-schema.html)

OLAP Overview (cont.)

BASIS FOR COMPARISON	STAR SCHEMA	SNOWFLAKE SCHEMA
Structure of schema	Contains fact and dimension tables.	Contains sub-dimension tables including fact and dimension tables.
Use of normalization	Doesn't use normalization.	Uses normalization and denormalization.
Ease of use	Simple to understand and easily designed.	Hard to understand and design.
Data model	Top-down	Bottom-up
Query complexity	Low	High
Foreign key join used	Fewer	Large in number
Space usage	More	Less
Time consumed in query execution	Less	More comparatively due to excessive use of join

"The crucial difference between Star schema and snowflake schema is that star schema does not use normalization whereas snowflake schema uses normalization to eliminate redundancy of data. Fact and dimension tables are essential requisites for creating schema." (techdifferences.com, 2017)

OLAP Overview (cont.)

- Multidimensional Databases
  - Each cell in these databases contains aggregated data related to the elements along each of its dimensions.
  - This structure is quite popular for analytical databases that use online analytical processing (OLAP) applications.

- Advantages of OLAP
  - It is a platform for all types of business including planning ,budgeting, reporting and analysis.
  - Information and calculations are consistent in an OLAP cube.
  - Quickly analyze “What if” scenarios.
  - Good for analyzing a time series.

- Disadvantages of OLAP
  - Requires the organization of data into either a star or snowflake schema.
  - You cannot have large number of dimensions in a single OLAP cube.
  - Transactional data cannot be accessed with an OLAP cube.

Types/Categories

- **Types: Multidimensional OLAP (MOLAP):**
  - this is the classic form of OLAP and is sometimes referred to as just OLAP. It stores data in an optimized multi-dimensional array storage, rather than in a normal relational database.
  - Some MOLAP tools require pre-computation and storage of derived data.
  - Some of these tools generally utilize a pre-calculated data set know as a data cube.

  - Advantages:
    - Fast query performance due to optimized storage
    - Smaller on-disk size of data compared to data stored in a relational database.
    - Very compact for low dimensions of data sets.

  - Disadvantages:
    - In some systems the data load process can be quite lengthy.
    - Some MOLAP methodologies introduce data redundancy.

Types/Categories (cont.)

- **Types: Relational OLAP (ROLAP):**
  - Works directly with relational databases and does not require pre-computation.
  - Depends on a specialized schema design.
  - Relies on manipulating the data stored in the database to give appearance of traditional OLAP slicing and dicing functionality.
  - Each action of slicing and dicing is equivalent to adding a “WHERE” clause in an SQL statement.
  - Does not use pre-calculated data cubes but instead poses the query to the standard relational database.
  - Generally the database must be more carefully designed for ROLAP. A database designed for OLTP will not function well for a ROLAP database.

Types/Categories (cont.)

- **Types: Relational OLAP (ROLAP): (cont.)**
  - Advantages:
    - Considered more scalable in handling large data volumes.
    - Ability to fine-tune the extract, transform, and load (ETL) code to the particular data model.
    - Data stored in the relational database can be accessed via any SQL reporting tool.
    - ROLAP tools are better at handling non-aggregatable facts.
  - Disadvantages:
    - There is consensus in the industry that ROLAP tools have slower performance than MOLAP tools.
    - Loading of aggregate tables must be managed by custom ETL code.
    - Not suitable when the model is heavy on calculations which don't translate well into SQL.

Types/Categories (cont.)

- **Types: Hybrid OLAP (HOLAP):**
  - A combination of ROLAP and MOLAP.
  - Developed to combine the greater data capacity of ROLAP with the superior processing capability of MOLAP.
  - The database will divide data between relational and specialized storage.
  - The HOLAP tools can utilize both pre-calculated cubes and relational data sources.
  - Stores aggregations in MOLAP for fast query performance.
  - Stores some slice of data, usually the most recent one, for fast query performance and older data in ROLAP.

Types/Categories (cont.)

- **Types: Hybrid OLAP (HOLAP): (cont.)**
  - Advantages:
    - HOLAP is best used when large amounts of aggregations are queried often with little detail data, offering high performance and lower storage requirements.
    - Cubes are smaller than MOLAP since the detail data is kept in the relational database.
    - Processing time is less than MOLAP since only aggregations are stored in multidimensional format.
    - Low latency since processing takes place when changes occur and detail data is kept in the relational database.
  - Disadvantages:
    - As slow as ROLAP when you try to access leaf level data.
    - Need to process when new records inserted.

(http://www.msbiguide.com/what-is-holap-and-its-advantages-and-disadvantages/)

Types/Categories (cont.)

- **Types: Other Types**
  - **WOLAP:** Web based OLAP – most appealing feature is the low investment involved given a user only needs to have an internet connection and web browser to access.
  - **DOLAP:** Desktop OLAP – based on the idea that a user can download a section of data from database/source and work on it locally.
  - **RTOLAP:** Real-time OLAP
  - **GOLAP:** Graph OLAP
  - **CaseOLAP:** Context-aware Semantic OLAP – developed for biomedical applications.
  - **Mobile OLAP:** Mainly refers to OLAP functionality on a wireless or mobile device.
  - **Spatial OLAP**: Aimed at the integrating the capabilities of both Geographic Information Systems (GIS) and OLAP into a single user interface, SOLAP. Created to facilitate management of both spatial and non-spatial data given that data can come not only alphanumeric but also as images and vectors.

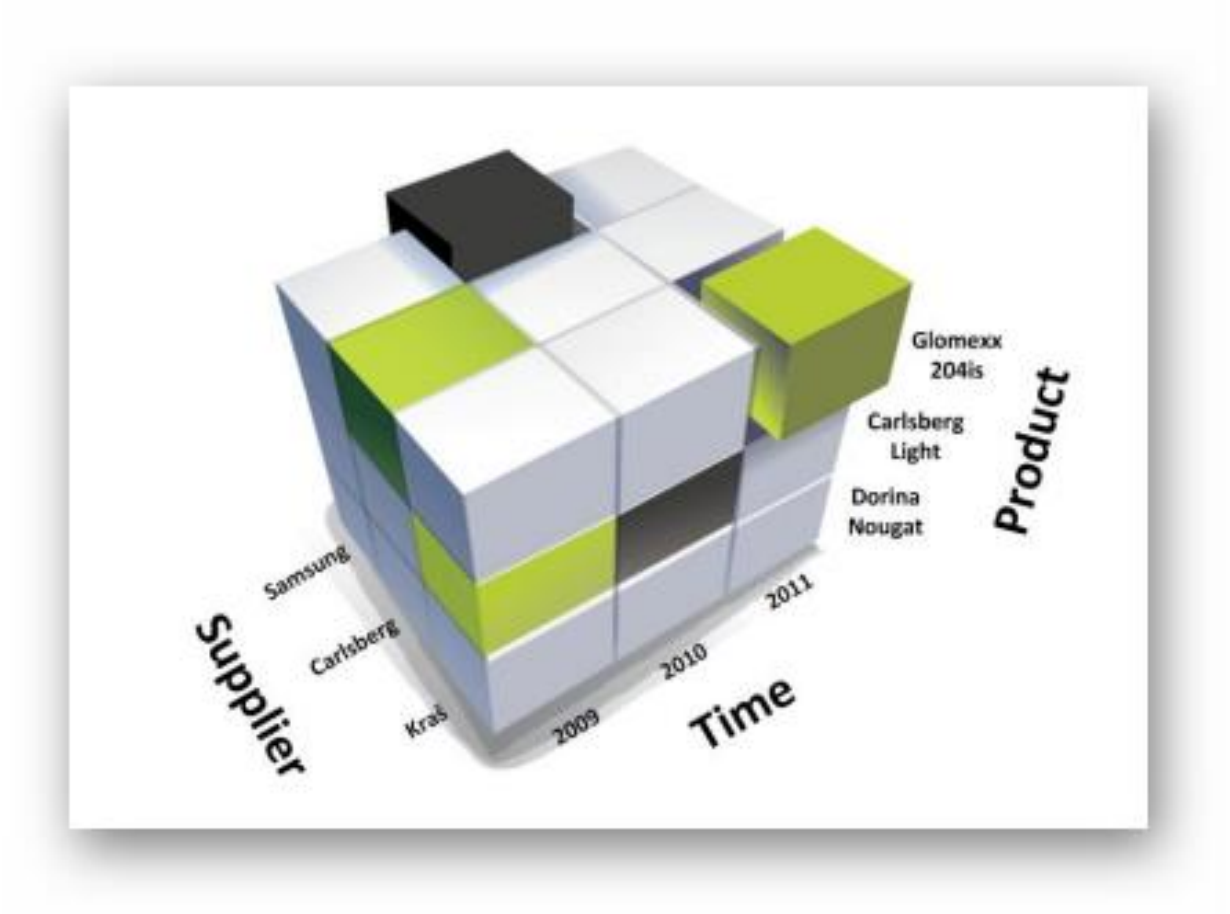
Types/Categories (cont.)

- **Open Source**
  - Mondrian OLAP – open-source server written in Java.
  - Druid – a popular open-source distributed data store for OLAP.
  - Apache Kylin – developed by eBay.
  - Cubes (OLAP Server) – a light-weight open-source toolkit implementation of OLAP functionality written in the Python programming language with built-in ROLAP.
  - Apache Point – used at LinkedIn, Uber, Slack and Microsoft to deliver scalable real time analytics.

OLAP CUBS

Cubes

OLAP Cube Representation

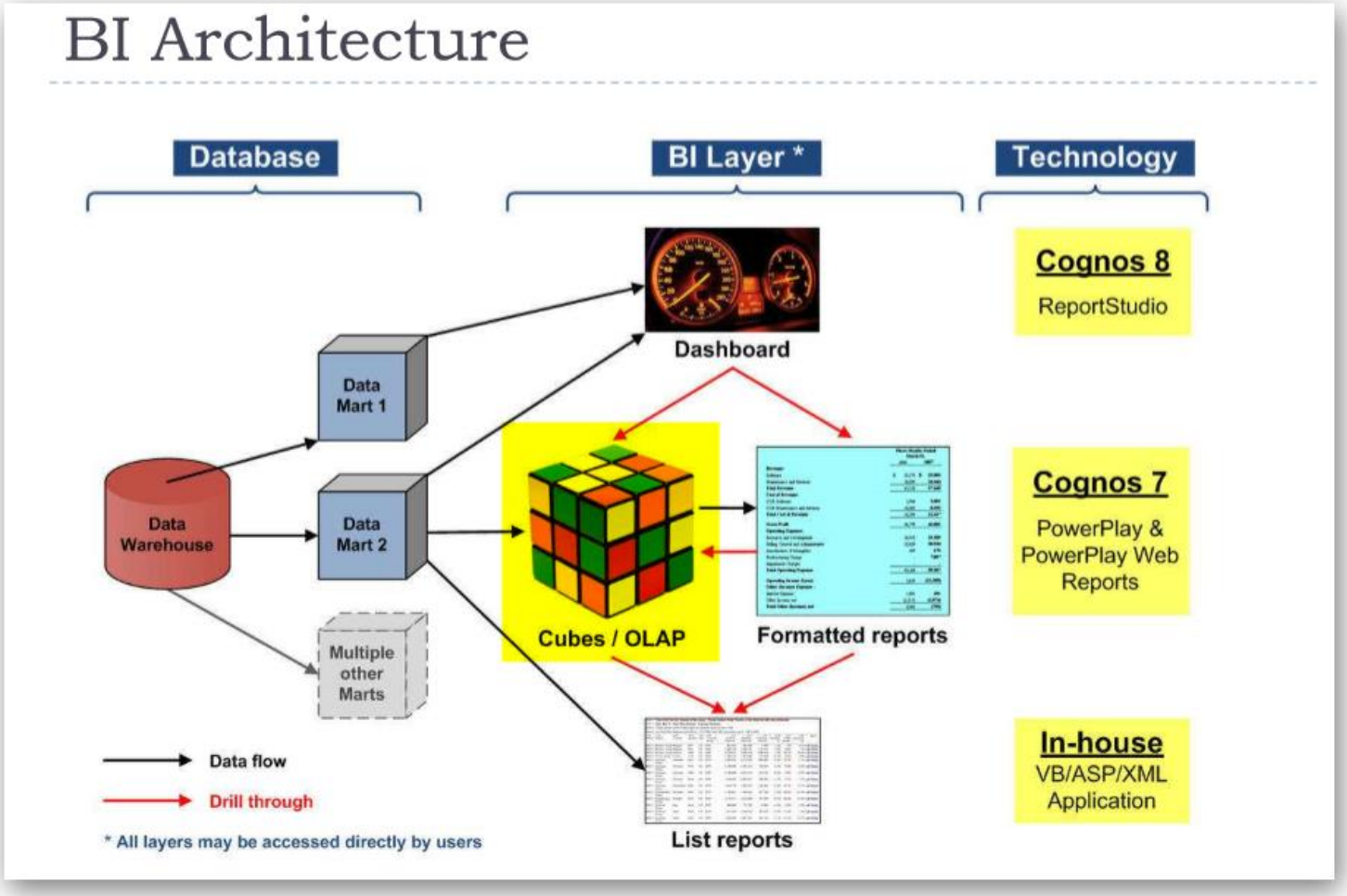


(https://pdfs.semanticscholar.org/5dfa/a21732d8bcaf4a095abe8b1d9e7db1de3257.pdf)

Cubes (cont.)

- The OLAP cube is a data structure that allows for the fast processing of data.
- Consist of numeric facts called ***measures*** which are then categorized by ***dimensions***.
- The cube metadata (structure) can be created from either a star schema or snowflake schema tables from a relational database.
- In OLAP cubes, data (measures) are categorized by dimensions. The **measures** are derived from the records in the fact table and **dimensions** are derived from the **dimensions** table.
- An OLAP cube is a method of storing data in a multidimensional form, generally for reporting purposes.
- OLAP cubes are often pre-summarized across dimensions to drastically improve query time over relational databases.

Cubes (cont.)



(Upadhyay, 2010)

Cubes (cont.)

- The OLAP cube is a data structure that allows for the fast processing of data.
- Consist of numeric facts called ***measures*** which are then categorized by ***dimensions***.
- The cube metadata (structure) can be created from either a star schema or snowflake schema tables from a relational database.
- The **measures** are derived from the records in the fact table and **dimensions** are derived from the **dimensions** table.

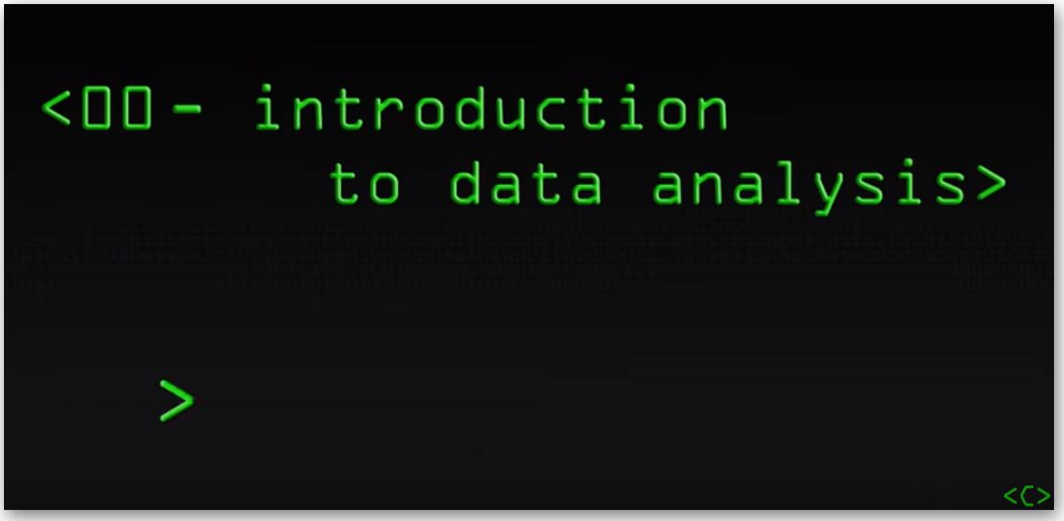
Cubes (cont.)

- Although it stores data like a traditional database does, an OLAP cube is structured very differently.
- Databases, historically, are designed according to the requirements of the IT systems that use them. OLAP cubes, however, are used by business users for advanced analytics.
- Thus, OLAP cubes are designed using business logic and understanding.
- They are optimized for analytical purposes, so that they can report on millions of records at a time. Business users can query OLAP cubes using plain English. (https://searchdatamanagement.techtarget.com/definition/OLAP-cube)

DATA ANALYSIS

Data Analysis

Video on data analysis



https://youtu.be/8GIbOJtUw8w

Type of Data Analytics

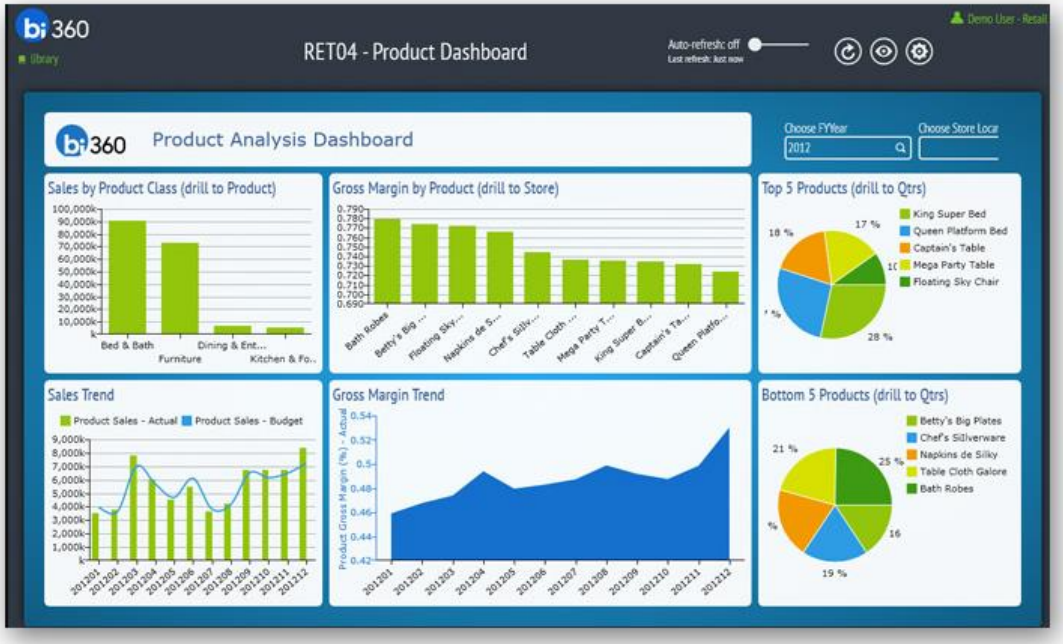
4 types of data analytics

Type of analytics	Explanation	Examples
Descriptive analytics	Provides insight based on past information. What is happening?	Used in standard report generation and in basic spreadsheet functions such as counts, sums, averages, and percent changes and in vertical and horizontal analyses of financial statements.
Diagnostic analytics	Examines the cause of past results. Why did it happen?	Used in variance analyses and interactive dashboards to examine the causes of past outcomes.
Predictive analytics	Assists in understanding the future and provides foresight by identifying patterns in historical data. What will happen? When and why?	Can be used to predict an accounts receivable balance and collection period for each customer and to develop models with indicators that prevent control failures.
Prescriptive analytics	Assists in identifying the best option to choose to achieve the desired outcome through optimization techniques and machine learning. What should we do?	Used in identifying actions to reduce the collection period of accounts receivable and to optimize the use of payables discounts.

(https://www.journalofaccountancy.com/issues/2016/aug/data-analytics-skills.html)

Type of Data Analytics (cont.)

- **Descriptive Analysis**
  - The foundation of all data insight.
  - It is the simplest and most common use of data today.
  - It answers the question “what happened” by summarizing past data usually in the form of dashboards. (See sample below)



(https://www.erpsoftwareblog.com/wp-content/uploads/Retail-Dashboards-for-NAV1.jpg)

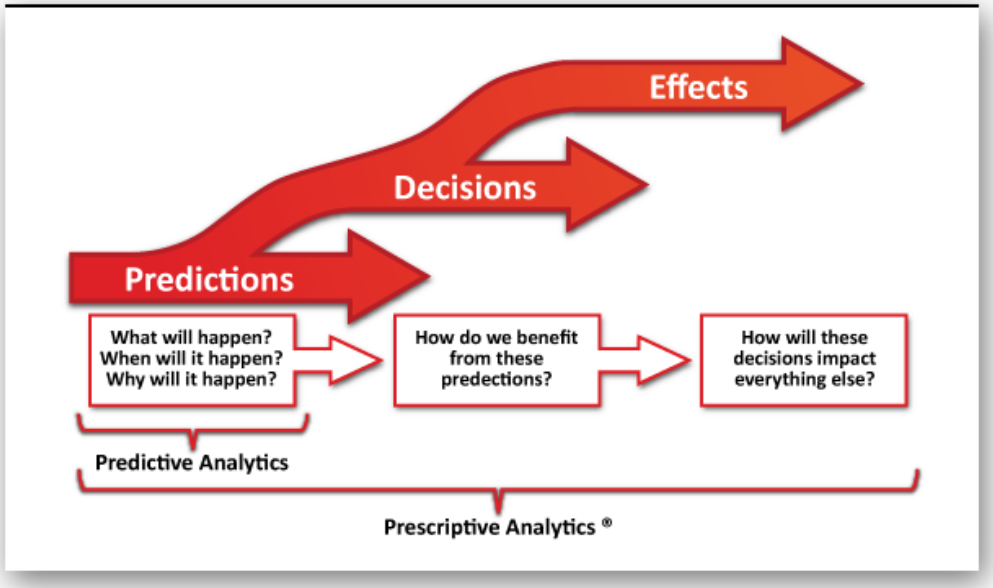
Type of Data Analytics (cont.)

- **Diagnostic Analysis**
  - After asking "*what happened*" you may want to dive deeper into the data and ask "*why did it happen*", and this is where diagnostic analysis comes into play.
  - Takes the insight found from descriptive analytics and drills down to find the cause of the outcome.
  - A critical aspect here is creating detailed information.

- **Predictive Analysis**
  - Attempts to answer the question "*what is likely to happen*".
  - Utilizes previous data to make predictions about future outcomes.
  - This type of analysis is yet another step up from both description and diagnostic analysis.
  - Uses the data which was summarized to make a logic prediction of the outcome of events.

Type of Data Analytics (cont.)

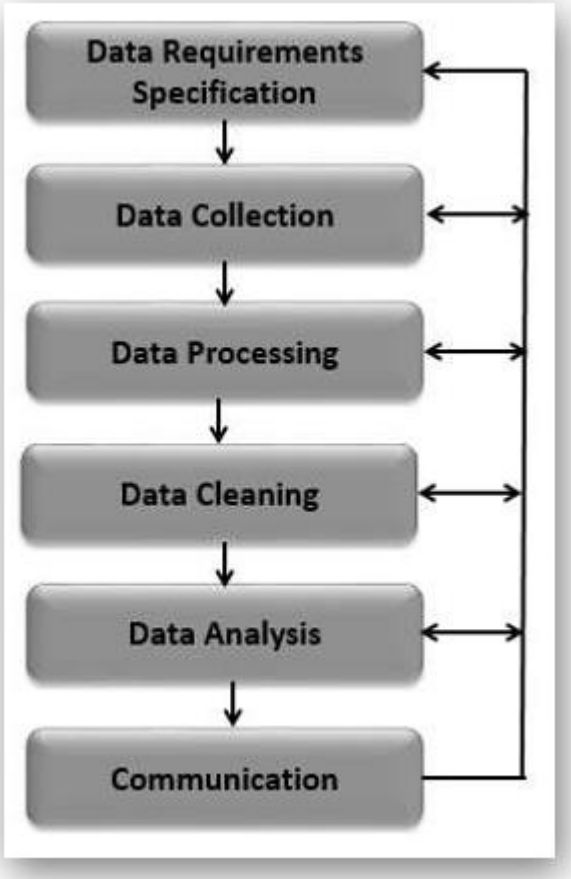
- **Prescriptive Analysis**
  - This final type of analysis is the most sought after.
  - It is the frontier of data analysis, combining the insights from all previous analysis to determine the course of action to take given the current situation/problem.
  - Utilizes state of the art technology and data practices.
  - Artificial Intelligence (AI) is a perfect example of this type of analysis.



(https://en.wikipedia.org/wiki/Prescriptive_analytics#/media/File:Three_Phases_of_Analytics.png)

Data Analysis Process

- This is the process of collecting, transforming, cleaning, and modeling data with the main goal of discovering the required information.
- Consists of the following phases:
  - Data Requirements Specification
  - Data Collection
  - Data Processing
  - Data Cleaning
  - Data Analysis
  - Communication



(https://www.tutorialspoint.com/excel_data_analysis/data_analysis_process.htm)

Data Analysis Process (cont.)

- Data Requirements Specification
  - The data required for analysis is based on a question or an experiment. Data may be numerical or categorical.
- Data Collection
  - The process of gathering information on targeted variables identified during data requirements.
  - Provides a baseline to measure and a target to improve.
  - Here the data collected is required to be subjected to data processing and data cleaning.
- Data Processing
  - The collected data must be processed or organized for use in analysis.
- Data Cleaning
  - The process of preventing and correcting errors which may have occurred in the collected data such as being incomplete or duplicative.

Data Analysis Process (cont.)

- Data Analysis
  - The data is processed, organized and cleaned and is now ready for analysis.
  - Here data visualization may be used to examine the data in a graphical format, to obtain insight regarding the messages within the data.
- Communication
  - Here the data analysis are reported in a format as required by the users to support their decisions and any further actions.

How is data analysis performed?

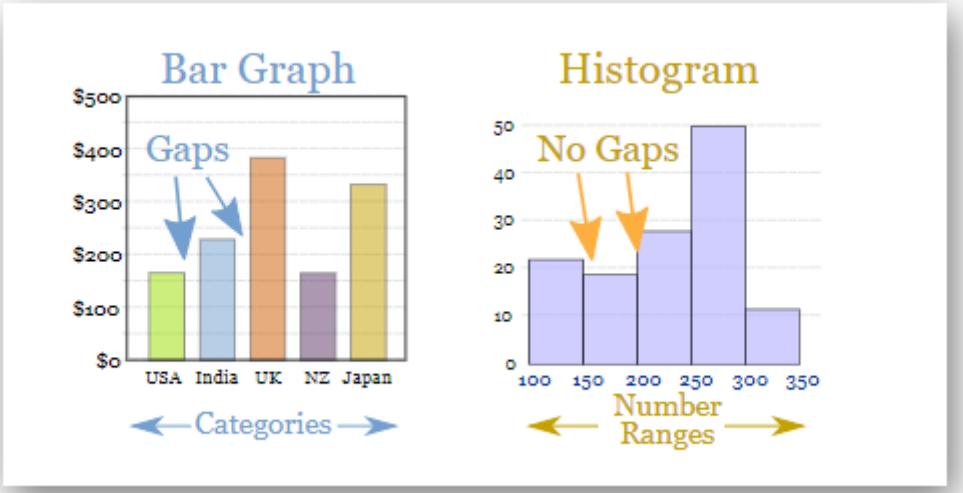
- This process usually includes one or more of the following steps:
  - Defining objectives
    - Must being with a clear set of clearly defined business objectives.
  - Posing questions
    - Here an attempt is made to ask a question in the problem domain.
  - Data collection
    - Data relevant to the question must be collected from the appropriate sources.
  - Data wrangling
    - Raw data may be collected in several different formats.
    - Must be cleaned and converted so that data analysis tool can import it.
  - Data analysis
    - The step where the cleaned and aggregated data is imported into the analysis tool.
    - The data is then analyzed to make sense of it for reporting purposes.
  - Drawing conclusions / Making predictions
    - The step where, after sufficient analysis, conclusions can be drawn from the data and appropriate predictions can be made.

How is data analysis performed? (cont.)

- Some detail in the data analysis phase contains the following:
  - Data Mining
    - A method of data analysis for discovering patterns in large data sets using the methods of statistics, artificial intelligence, machine learning and databases.
  - Text Analytics
    - The process of deriving useful information from text.
    - Accomplished by processing unstructured textual information, extract meaningful numerical indices from the that information and make it available to statistical and machine learning algorithms for further processing.
    - The text mining phase contains one or more of the following steps:
      - Collecting information
      - Linguistic analysis
      - Pattern recognition
      - Extracting summary information
      - Analyzing open-ended survey responses
      - Analysis of emails, documents, etc. to filter out “junk”.
      - Investigate competitors by crawling their websites.
      - Security applications which can process log files for intrusion detection.

How is data analysis performed? (cont.)

- Data Visualization
  - Refers very simply to the visual representation of the data.
  - Means using tools of statistics, probability, pivot tables and other artifacts to present data visually.
  - Used in the following applications:
    - Extracting summary data from raw data.
    - Using a bar chart to represent sales performance over several quarters.
    - A histogram shows distribution of a variable such as income by dividing the range into bins.



(https://www.mathsisfun.com/data/histograms.html)

Methods & Techniques

- Data analysis methods focus on strategic approaches of taking raw data, mining for details that are relevant to the business's primary goals, then drilling down into that information.
- The top 10 data analysis methods & techniques are discussed below
  - Collaborate your needs
  - Establish your questions
  - Harvest your data
  - Set key performance indicators (KPIs)
  - Omit useless data
  - Conduct statistical analysis
  - Build a data management roadmap
  - Integrate technology
  - Answer your questions
  - Visualize your data

Tools

Some examples of data analysis tools

(https://www.guru99.com/what-is-data-analysis.html)

Benchmark for evaluation of OLAP Tools

- Researcher Fiaz Majeed (2017) presented the following evaluation criteria for OLAP tools which contains the seven parameters shown.
  - Interface
  - Query
  - Drill-down options
  - Roll-up options
  - Aggregation function support
  - Data access
  - Performance

  The next few slides will detail each of the above items.

Benchmark for evaluation of OLAP Tools (cont.)

- **Interface**: This is the fundamental source of communication between the user and the system. The interface is evaluated based on the following features:
  - Design
  - User-friendly
  - Type
  - User type
  - Visualizations
  - Interactive
  - Complexity

Benchmark for evaluation of OLAP Tools (cont.)

- **Query**: Is evaluated based on:
  - Format
  - Procedure
  - Drill-down options
  - Expertise required
  - Training required

- **Drill-down options**:
  - Support
  - Options
  - Point and click
  - Grouping different way
  - Complexity

Benchmark for evaluation of OLAP Tools (cont.)

- **Roll-up options**:
  - Support
  - Options
  - Point and click
  - Grouping different way
  - Dimensions selection

- **Aggregation function support**
  - Tools are tested based on their aggregation functions supported /provided to users.
- **Data access**
  - Tools are analyzed by data type supported by them.
- **Performance**
  - Measured by analyzing the response time by input queries to the tool.

Data Analytic Tools

There is a whole host of available applications for companies to choose from when selecting data analysis tools. Here we will focus on the leaders in this space and provide some detail about their tools.

- **Tableau**
  - This tool features robust functionality with fast speed.
  - Has connectivity to many different local and cloud-based data sources.
  - It combines data sourcing, preparation, exploration, analysis and presentation in one streamlined workflow.

- **PowerBI**
  - Suite of business analytic tools developed by Microsoft and thus integrated with Microsoft Office.
  - Based on both on-premise and in-cloud service.
  - Became popular due to its powerful functionalities, and is believed to be the industry leader in this field.

Data Analytic Tools (cont.)

- **R Programming**
  - A leading analytics tool widely used for statistics and data modeling.
  - Runs on a variety of platforms like Unix, Windows and MacOS.
  - Has over 11,556 different packages users can browse by categories', and has tools to automatically load packages based on your requirements.

- **SAS**
  - A programming environment and language for data manipulation.
  - Is a leader in analytics which was developed by the SAS Institute in 1966, and futhark developed in the 1980's and 1990's.
  - Is easily accessible, manageable and can analyze data from any source.

- **RapidMiner**
  - A powerful integrated data science platform
  - Can incorporate with any data source types including Access, Excel, SQL, Oracle, etc.
  - Can generate analytics based on real-life data transformation settings.

Data Analytic Tools (cont.)

- **Looker**
  - Strives to provide a unified data environment and centralized data governance.
  - Has a heavy emphasis on reusable components for data-savvy users.
  - Using an ETL approach this application gives the users the ability to model and transform data as they need.
  - Also features a proprietary LookML language which harnesses SQL in a visual and reusable way.

- **MicroStrategy**
  - One of the older data analytic platforms founded in 1989.
  - Has the robustness users would expect from such a mature toolset.
  - Connects to numerous enterprise assets like ERPs and cloud and data vendors.
  - Enhances data governance by using end-point telemetry to manage user access.

Assignment Due Dates

Assignment List

Assignment Name	Due Date	Type
Unit 1 - Discussion Board	Fri, 4/10/20	Discussion Board
Unit 1 - Discussion Board 2	Tue, 4/14/20	Discussion Board
Unit 1 - Individual Project	Wed, 4/15/20	Individual Project
Unit 2 - Discussion Board	Tue, 4/21/20	Discussion Board
Unit 2 - Individual Project	Wed, 4/22/20	Individual Project
Unit 3 - Discussion Board	Tue, 4/28/20	Discussion Board
Unit 3 - Individual Project	Wed, 4/29/20	Individual Project
Unit 4 - Discussion Board	Tue, 5/5/20	Discussion Board
Unit 4 - Individual Project	Wed, 5/6/20	Individual Project
Unit 5 - Discussion Board	Tue, 5/12/20	Discussion Board
Unit 5 - Individual Project	Wed, 5/13/20	Individual Project

Unit 4 – Individual Project

Assignment

In this assignment, the section "Data Analysis" will be added to this report. The report will be submitted as the first draft of the Key Assignment.
The following sections of the Data Warehouse Design Document should now be complete:
•Data Warehouse Requirements
•Design Requirements
•Load Data
•Data Analysis

The project deliverables are the following:
•Update the Data Warehouse Design Document title page with a new date and project name.
•Update the previously completed sections based on your instructor's feedback.
•**Week 4: Data Analysis**

- Define what online analytical processing (OLAP) means.
- Discuss what OLAP tools are available for use in a data warehouse.
- Discuss how you will utilize OLAP to query the warehouse and perform data analysis tasks. Give examples.

•Be sure to update your table of contents before submission.
•Name the document "yourname_CS683_IP4.doc."
•Submit the document for grading.
Note: This is the Key Assignment draft that you are also submitting to the Discussion Board.

Unit 4 – Individual Project

Worked Example

- Please refer to the Worked Example below for an example of this assignment based on the Problem-Based Learning Scenario. The worked example is not intended to be a complete example of the assignment but will illustrate the basic concepts required for completion of the assignment and can be used as a general guideline for your own project. Your assignment submission should be more detailed and specific and should reflect your own approach to the assignment rather than just following the same outline provided in the worked example.

Case Study: Problem 4

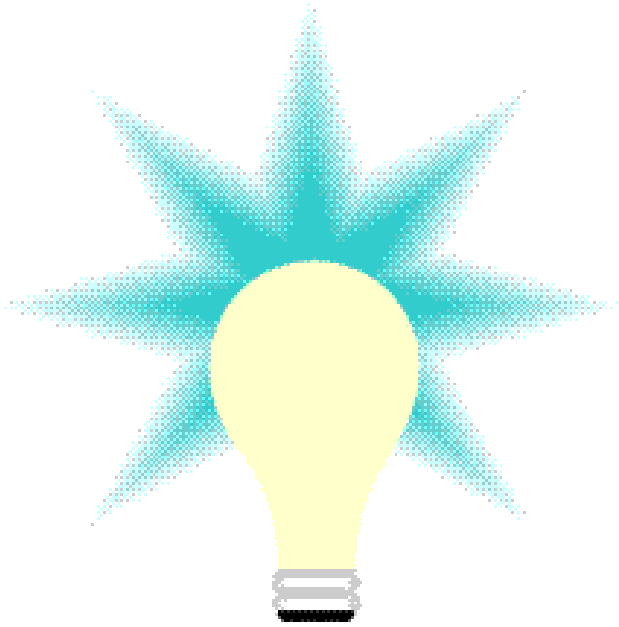
- The data warehouse committee has received the first 3 phases of the data warehouse design document (requirements defined; physical, conceptual, and logical design; and extract, transform, and load [ETL]). The data warehouse committee would like to see the new and improved customer data that are now available in the data warehouse. They want to be able to query the data warehouse to see the customers' account information, sales, and marketing information.
- Note that the worked example includes material from previous worked examples. The new material will be found under the Week 4 sections of the Table of Contents.
- The worked example is provided here to help with this assignment.
- **Please submit your assignment.**
- **For assistance with your assignment, please use your text, Web resources, and all course materials.**

Contact Information

- My e-mail address- JConklin@coloradotech.edu
- Office Hours - Wednesday 6:00 P.M. – 7:00 P.M. CST
  Saturday 11:00 A.M. – 12:00 P.M. CST
- Live Chats - Thursday 7:00 P.M. – 8:00 P.M. CST

* Please note that only one live chat session per week is required for this course. However, optional live chat sessions may be held sporadically throughout the course.

Questions / Comments



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